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Forecasting a Fatal Decision: Direct Replication of the Predictive Validity of the
Suicide-Implicit Association Test

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The authors declare no conflicts of interest. A. Chatard developed the study concept and N. Tello collected the data. N. Tello and A. Chatard conducted the data analysis and wrote the manuscript. G. Harika-Germaneau, W. Serra, and N. Jaafari provided assistance with patient recruitment and critical revisions. All authors approved the final version of the manuscript for submission.

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Abstract

Research has suggested that implicit identification with death/suicide can accurately predict a suicide attempt several months in advance (Nock et al., 2010). We report the first direct and independent replication of this promising finding. Participants included 165 patients seeking treatment at a psychiatric unit in France. At baseline, patients completed the Suicide-Implicit Association Test (S-IAT), a semistructured interview, and a self-report measure of suicide ideation. Six months later, we contacted the patients by phone and examined their hospital medical records, to determine whether they had made a new suicide attempt. Results showed that the S-IAT did not discriminate patients who presented for suicide attempts (vs. other reasons). As in the original study, however, the S-IAT predicted suicide attempts within the 6-month follow-up period beyond well-known predictors. The test correctly classified 85% of patients, 95% CI [76.91, 91.53], supporting its diagnostic value for identifying who will make a future suicide attempt.

Keywords: Implicit Association Test, implicit identification, death/suicide, suicide attempt, direct and independent replication

Forecasting a Fatal Decision: Direct Replication of the Predictive Validity of the Suicide-Implicit Association Test

Predicting suicide is a difficult and complex challenge (Carter et al., 2017; Franklin et al., 2017; Woodford et al., 2019). However, researchers recently suggested that a new behavioral test and algorithm assessing implicit identification with death/suicide can accurately predict suicidal behavior (Nock et al., 2010). Using a sample of 157 patients seeking treatment at a psychiatric emergency department in the United States, Nock et al. (2010) found that the Suicide-Implicit Association Test (S-IAT) discriminated patients who presented for suicide attempts and those who presented for other psychiatric reasons. Even more interestingly, the S-IAT prospectively predicted suicide attempts over a 6-month follow-up period, over and beyond well-known predictors. This and other recent studies have offered new insights into the prediction and prevention of suicidal behaviors.

From a theoretical viewpoint, Nock et al.'s (2010) findings are important, because they contributed to a growing body of work showing that the implicit association test (IAT) has good predictive validity (Faure, Righetti, Seibel, & Hofmann, 2018; Glenn, Werntz et al., 2017; Greenwald, Poehlman, Uhlmann, & Banaji, 2009; Kurdi et al., 2018; Nock & Banaji, 2007; Roland, Mierop, Frenay, & Corneille, 2018; Serra et al., 2019). The question of whether the IAT can predict complex behavior over and above existing measures has generated considerable debate and controversy in social psychology (for a recent review, see Jost, 2018), where the test was initially proposed (Greenwald, Nosek, & Banaji, 2003). By showing that the IAT can prospectively predict real-life behavior better than other well-known predictors, Nock et al. (2010) contributed to this important scientific debate.

From a practical viewpoint, Nock et al.'s (2010) results may have implications for the detection of suicidal risk in clinical populations. Suicide is a leading cause of death worldwide, and suicide rates have been on the rise over the last 20 years (World Health Organization, 2014). Thus, accurate prediction of suicide attempts is more important than ever. Nevertheless, our capacity to predict suicide remains insufficient (for a meta-analysis, see Franklin et al., 2017), and clinicians still base their clinical judgments on their experience and patient reports. These indicators have limited predictive validity (for meta-analyses, see Carter et al., 2017; Woodford et al., 2019), due in part to patients' tendency to conceal or deny suicidal thoughts. Patients may also be unable to report on their suicidal intention if automatic cognitive processes that are hardly accessible to introspection, such as implicit bias, shape their behavior. In this context, improving our means of detecting patients at risk of suicide seems very important. Nock et al.'s (2010) findings may provide solutions to this pressing medical and societal issue.

Because replication is the cornerstone of scientific progress (Open Science Collaboration, 2015), the next step should be to test whether Nock et al.'s (2010) findings can be replicated directly and independently. Recently, concerns related to publication bias (Rosenthal, 1979), questionable research practices (such as p-hacking, John, Loewenstein, & Prelec, 2012), and failures to replicate (Maxwell, Lau, & Howard, 2015; Open Science Collaboration, 2015) have led to a confidence crisis in science. Some researchers doubt the validity and reproducibility of most published research (Ioannidis, 2005; Pashler & Wagenmakers, 2012). This crisis underscores the importance of direct replication in science (Simons, 2014). Direct replication aims to reduce publication bias, and the use of questionable research practices, by using—as

closely as possible—the same methods and procedures as the original study. Direct replications are essential, to estimate the real effect size of a phenomenon (Klein et al., 2018). Unfortunately, direct replication is currently rare in clinical science (Tackett et al., 2017).

A cursory reading of the literature suggested that Nock et al.'s (2010) study has been replicated many times. Upon further analysis, however, it became clear that the studies were conceptual, rather than direct replications. For example, researchers have used different populations (e.g., adolescents; cf. Nock & Banaji, 2007), nonclinical samples (Glenn, Kleiman, Cha, Nock, & Prinstein, 2016; Glenn, Werntz et al., 2017), different versions of the IAT (Glenn et al., 2016; Nock & Banaji, 2007), and different statistical analyses (Randall, Rowe, Dong, Nock, & Colman, 2013). Some studies found results consistent with the original findings (i.e., mean differences in the S-IAT between clinical and nonclinical groups), while others did not (Barnes et al., 2017; Glenn, Kleiman et al., 2017; Glenn, Werntz, et al., 2017). As far as we know, apart from these conceptual replications, there has been no direct replication of Nock et al.'s (2010) study. Although conceptual replications have merit, researcher degrees of freedom in conceptual replications may increase the likelihood of false positive research findings (Simmons, Nelson, & Simonsohn, 2011).

Independent replications are also important, because replications are more likely to succeed when led by the same team (Makell, Plucker, & Hegarty, 2012). Most studies conducted thus far on the S-IAT were coauthored by Nock and colleagues. Other studies carried out by independent teams have produced mixed findings. For instance, Chiurliza et al. (2018) found that the S-IAT was not related to a history of suicidal ideation among 1,548 U.S. military service members. In the same way,

Harrison, Stritzke, Fay, and Hudaib (2018) found little evidence that the S-IAT prospectively predicted suicide risks in a clinical sample, above and beyond clinician prediction.

The goal of the present study was to provide one of the most thorough and rigorous replication studies in clinical science to date: a direct and independent replication of the Nock et al. (2010) study. We reasoned that an implicit bias that is common among individuals who consider killing themselves is an automatic tendency to identify the self with death/suicide. This implicit bias, which may develop through repeated thoughts that one will be better off dead than alive, may predict suicidal behaviors, even if patients are unwilling or unable to report suicidal thoughts. Similar to Nock et al. (2010), we expected that patients who presented to the emergency department after a suicide attempt would have a statistically significantly stronger implicit association between self and death/suicide than would patients who did not make a recent suicide attempt. We also expected the S-IAT to predict future suicide attempts within a 6-month period over and beyond other clinical predictors (depressive disorder, multiple suicide attempts, current suicidal ideation, clinician prediction, and patient prediction).

Method

Preregistration

This study was initially designed as a preregistered direct replication. However, as explained in the Supplemental Online Material (SOM), various factors delayed the project and prevented us from conducting a formal registered report. We preregistered the study online on February 23, 2018 (<https://osf.io/2mh48/registrations>), using the

Open Science Framework (OSF). At this point, most data had already been collected. However, we did not code and analyze the data before the preregistration.

A Priori Power Analysis

The present sample was determined in advance to have at least 80% power to replicate Nock et al. (2010)'s original findings. The original study included 157 patients. The results showed that 43 patients who had made a suicide attempt in the week before their hospitalization had higher S-IAT scores than the other 114 patients (the control group), $t(157) = 2.46, p = .015$, Cohen's $d = 0.44$.¹ This is the first key result we sought to replicate in the present study. Nock et al. (2010) also found that after controlling for clinical predictors (any depressive disorder, multiple suicide attempts, suicide ideation, and patients' and clinicians' predictions), patients with high S-IAT scores (a continuous variable) at admission were more likely to make a suicide attempt by the 6-month follow-up, $OR = 30.68$, 95% CI [1.18, 795.12] than were patients with low S-IAT scores. This is the second key result we sought to replicate. The observed effect sizes were medium to large in the original study (Cohen's $d = 0.44$ for the first, and 1.88 for the second key result). We based the present study power analyses on the first key result reported by Nock et al. (2010), because it had the lowest effect size. Thus, a sample size sufficient to replicate this effect with 80% statistical power will necessarily have sufficient power to replicate the second key result. The power analyses revealed that we needed a total sample size of 162 patients to replicate the first key result in a one-tailed t test, with $\alpha = .05$, $1 - \beta = .80$, and the group allocation ratio (patients who presented for suicide attempts vs. other reasons) = 2.65. A one-sided t test seemed justified because (a) the prediction is unidirectional in a direct replication, (b)

the prediction is clearly specified in advance in a preregistered study, and (c) we had no interest in, and would not try, interpreting effects in the opposite direction.

Importantly, the group allocation ratio for the power analysis was based on Nock et al.'s (2010) study. There was no guarantee that this allocation ratio would be the same in this replication study. However, national suicide rates are higher in France, where the present replication study was conducted, than in the United States (World Health Organization, 2014). For that reason, we expected a greater proportion of patients who made a suicide attempt than in the original study. Thus, the power analysis provides a conservative estimate of the required total sample size. Of course, a larger sample would have been desirable. However, obtaining it was infeasible for practical reasons.

Participants

Participants were 165 adults (85 women and 80 men) seeking treatment at the psychiatric emergency department of Poitiers University Hospital, France. Fifty patients had made a suicide attempt within the previous week (see Table 1 for the sample characteristics). We used the same inclusion and exclusion criteria as those of Nock et al. (2010). We included any patients who were at least 18 years old and did not have an impairment that could affect their ability to comprehend and participate in the study (inability to speak French, cognitive impairment, and agitated or violent behaviors). One patient was excluded, because she declined to complete the last block of the S-IAT measure, leaving 164 patients in the final sample.

Procedure

This study was approved by the local ethical committee, and it was carried out in accordance with the provisions of the World Medical Association Declaration of

Helsinki. The procedure and stimuli were identical to those used in Nock et al.'s (2010) study. Professor Nock sent the material to us upon request. All the material, including the instructions and the word stimuli of the S-IAT, had been translated into French, using a translation-back-translation procedure (for a video of the French version of the S-IAT, see <https://osf.io/f97kc/>). Professor Nock was not consulted after the preparation of the research material, and he did not validate the French translations.

Table 1

Characteristics of the Sample

Variable	No suicide attempt within previous week ($n=115$)	Suicide attempt within previous week ($n=50$)	Statistical test	Effect size
Mean age (years)	43.93 (14.51)	39.6 (14.63)	$t(163) = 1.76$	$d = 0.29$, [−0.03, 0.63]
Sex (%)			$\chi^2(1) = 0.74$	$\Phi = 0.07$
Women	48.70	56		
Men	51.30	44		
Psychopathology (%)				
Any depressive disorder	82.6	88	$\chi^2(1) = 0.76$	$\Phi = 0.07$
Any psychotic disorder	5.2	2	$\chi^2(1) = 0.88$	$\Phi = 0.07$
Any anxiety disorder	80.9	78	$\chi^2(1) = 0.18$	$\Phi = 0.03$
Any eating disorder	2.6	8	$\chi^2(1) = 2.50$	$\Phi = 0.12$
Any addiction	11.3	14	$\chi^2(1) = 0.24$	$\Phi = 0.04$
Any alcohol use disorder	25.2	30	$\chi^2(1) = 0.41$	$\Phi = 0.05$
Any other disorder	33.9	20	$\chi^2(1) = 3.23$	$\Phi = 0.14$
Mean number of mental disorders	2.4 (0.93)	2.4 (1.11)	$t(163) = 0.10$	$d = 0.02$
Previous suicide attempts (%)			$\chi^2(1) = 3.6$	$\Phi = 0.00$
No previous attempt	54.8	50		
One previous attempt	27.8	20		
Multiple previous attempts	17.4	30		

Note. For means, standard deviations are given in parentheses. For effect size (Cohen's d), 95% confidence intervals are given in brackets.

All participants had been admitted to the psychiatric department, and had been first evaluated by a member of clinical staff, and if necessary, had been hospitalized.

Subsequently, we described the study to participants who met the inclusion criteria, and invited them to participate. The participants were informed of the topic of the study, and asked for consent. Similarly to Nock et al. (2010), we included a brief cognitive impairment measure by asking several true/false questions about the study at the end of the consent form, to ensure that patients had a good understanding of the study. The patients who responded correctly were invited to participate. Consenting patients completed all measures in a small office at the hospital or in their hospital beds. First, they completed the S-IAT (Nock et al., 2010), followed by the Self-Injurious Thought and Behaviors Interview (SITBI; Nock, Holmberg, Photos, & Michel, 2007), and finally, the Beck Scale for Suicide Ideation (BSSI; Beck, Kovacs, & Weissman, 1979). Six months later, patients were contacted by phone, and completed the SITBI and the BSSI again. We also examined the patients' hospital medical records to determine whether they had returned to the hospital due to suicide attempts during the 6-month period.

Measures

Suicide-Implicit Association Test. The S-IAT is a computerized test of automatic mental associations between two concepts, "Me" and "Death". The S-IAT is based on reaction times to categorize stimuli that appear in the middle of the screen into one of two categories, "Death" (i.e., *die, deceased, funeral, lifeless, and suicide*) and "Life" (i.e., *alive, survive, live, thrive, and breathing*), and/or into one of two attribute categories, "Me" (i.e., *I, myself, my, mine, and self*) and "Not Me" (i.e., *they, them, their, theirs, and other*). Category names appear in the top left and the top right corners of the screen. Participants have to choose whether the stimulus belongs in the category on the left, by pressing the "E" key, or in the category on the right, by pressing the "I"

key. The S-IAT is composed of seven blocks. Blocks 1, 2, and 5 are practice blocks. Blocks 3 and 4 are congruent blocks, in which congruent categories share the same response key. “Congruence” is defined by the hypothesis being tested. In the present study, we defined “Me” and “Death”, as well as “Not me” and “Life”, as congruent category pairs. In contrast, “Me” and “Life”, as well as “Not me” and “Death”, were defined as incongruent category pairs. Blocks 6 and 7 are incongruent blocks, in which incongruent categories share the same response key.²

The reliability of the S-IAT, as estimated by a split-half method with Spearman-Brown correction, was very good ($r_{sb} = .89$). The S-IAT scores were computed using the improved D600 algorithm (Greenwald et al., 2003). Positive scores represent a strong implicit association between self and death/suicide. There is no extreme-value treatment in the D600 algorithm (Greenwald et al., 2003, p. 214). However, two outliers were detected in the present sample, with atypical and extreme values on the S-IAT (with z-scores above 3 standard deviations [*SD*] from the mean). Because these atypical observations exerted a disproportional influence on the analyses, and may have led to spurious conclusions (Osborne & Overbay, 2004), we removed them from the data set before we conducted the main analyses. However, all statistically significant results remained statistically significant, when outliers were included in the analyses (see the results section). Consistent with previous studies, the IAT scores were positively related to explicit suicidal ideation measured at baseline, $r(161) = .17, p = .031, 95\% \text{ CI } [.01, .31]$.

Demographic and psychiatric factors. To test the incremental predictive validity of the IAT, we assessed known demographic and psychiatric risk factors for

suicide attempts. We considered participants' age, sex, and the primary psychiatric diagnosis (evaluated with the Mini International Neuropsychiatric Interview).

History of suicidal behavior. We determined the group status at baseline (patients with a recent suicide attempt versus controls). We also measured the past history of suicidal behavior (the number of previous suicide attempts) at baseline, as previous suicide attempts are a strong predictor of subsequent suicide attempts (Nock et al., 2010). The history of suicidal behavior was assessed via the SITBI (Nock et al., 2007), a structured interview assessing participants' history of suicidal and self-injurious behaviors. This 169-question interview allowed us to distinguish among six behaviors: suicidal ideation, suicide plan, gesture, actual suicide attempt, thoughts of nonsuicidal self-injury, and nonsuicidal self-injury. Each section of this questionnaire focuses on one of these six behaviors, and begins with a screening question. If the patient has already engaged in the behavior in question, all items in the section are asked. The interview has good reliability and validity (Nock et al., 2007).

Suicide ideation. Patients also completed the Beck Scale for Suicide Ideation (Beck et al., 1979). This scale is a 19-item questionnaire designed to quantify, and assess, suicidal intention and ideation. The first five items assess the wish to die, and the intention to make a suicide attempt. The following items assess the frequency, duration, and controllability of suicidal thoughts. Subsequent items are related to the methods of suicide, the sense of "capability" to make a suicide attempt, and the expectancy/anticipation of an actual attempt. The last item assesses the motivation to deceive/reveal suicidal thoughts openly. Participants indicate their responses to each item on a 3-point Likert scale. The internal consistency of the scale was high in the present study (Cronbach's $\alpha = .91$, and $.94$, at baseline and follow-up, respectively).

Clinical and patient predictions. We asked the patient's primary therapist to predict the risk of a new suicide attempt ("Based on your clinical judgment and all that you know about this patient, if untreated, what is the likelihood that this patient will make a suicide attempt within the next 6 months?", with answers given on a scale of 0–10, with 0 representing *very low likelihood*, and 10 signifying *very high likelihood*). We also assessed the patient's own risk estimation, by asking him or her, "On a scale of 0 to 4, what is the likelihood that you will make a suicide attempt in the future?" These questions were asked to compare the predictive ability of the IAT to those of clinicians' and patients' predictions that are routinely used in psychiatric departments.

Follow-up assessment. We assessed the occurrence of suicide attempts during the 6-month follow-up period using two methods: We readministered the SITBI (Nock et al., 2007) by phone, and examined each patient's hospital medical record, to determine whether the patient had made a new suicide attempt and returned to the hospital. The two variables were binary-coded (0 = *No suicide attempt*, and 1 = *Suicide attempt*). As in Nock et al.'s (2010) study, a suicide attempt was considered to have occurred during the 6-month follow-up period if one of these two methods showed evidence of an attempt (0 = *No evidence*, and 1 = *Evidence of a suicide attempt*). The level of agreement between the two methods was $\kappa = .55$. According to Landis and Koch (1977), κ values between .41 and .60 indicate moderate agreement. Similarly, Fleiss's (1981) guidelines characterize kappas between .40 and .75 as fair to good.

Data analysis. The statistical analysis was performed with IBM SPSS Statistics 23.0 and JASP Version 0.9. All the data and code are available on the OSF. We performed the same analyses as in the original study. As in Nock et al. (2010), we used an independent sample *t* test to compare the performance on the S-IAT of participants

who had made a suicide attempt the week before and those who had not. We also tested whether the IAT scores prospectively predicted suicide attempts during the follow-up period beyond the effect of other well-known predictors. As in Nock et al. (2010), we used a hierarchical logistic regression analysis, in which we included any depressive disorders and multiple suicide attempts in the first step, suicide ideation and patients' and clinicians' prediction in the second step, and S-IAT scores (continuous variable) in the third step. As in Nock et al.'s (2010) study, we also examined whether S-IAT bias (IAT scores > 0 vs. IAT scores < 0) could prospectively predict a suicide attempt during the 6-month follow-up period beyond the effect of the other predictors.

Because we did not specify in advance a direction for the effects of the control variables, all p values reported in the text are two-tailed. However, the findings for the hypotheses are similar, when unidirectional, rather than bidirectional, tests are used.

Results

Deviation from the Preregistration

There were no deviations from the preregistered protocol. The main outcome measure (a suicide attempt within the 6-month follow-up period) was computed as in the original study. One issue that we did not anticipate, however, was that many patients did not respond to our phone calls at the 6-month follow-up (the response rate was 60% in the present study). Nock et al. (2010) did not report the response rate in their study, but it seems unlikely that all their patients could be reached by phone 6 months after discharge from the hospital. The attrition rate in our study was comparable to that found in other studies (Vaiva et al., 2006). In the present study, patients with missing data did not differ from the other patients in terms of demographic and psychiatric variables (see Table S1). Thus, missing data did not seem to be major problem. To provide converging

evidence for the findings, we conducted supplementary analyses with a multiple imputation technique for handling missing data. The results of this additional (nonpreregistered) analysis are discussed in the text, and reported in the SOM.

Preregistered Analyses

In contrast to the original study, patients admitted to the psychiatric emergency department after a suicide attempt did not have a statistically significantly stronger implicit association between self and death/suicide than control patients ($M = -0.55$, $SD = 0.35$, and $M = -0.54$, $SD = 0.39$, respectively), $t(160) = 0.14$, $p = .889$, $d = 0.024$, 95% CI $[-0.31, 0.36]$. Moreover, the S-IAT did not discriminate patients who had made a recent suicide attempt from control patients, $OR = 0.88$, 95% CI $[0.35, 2.16]$, after adjusting for depressive disorders and number of previous suicide attempts (see Table S2 of the SOM). Thus, we did not replicate Nock et al.'s (2010) first effect showing that the S-IAT discriminates patients who made a recent suicide attempt from other psychiatric patients admitted to the emergency department.

Descriptive statistics indicated that the mean of the S-IAT scores was lower among patients with no history of suicide attempts, $n = 60$, $M = -0.61$, 95% CI $[-0.69, -0.52]$, compared to previous suicide attempters, $n = 53$, $M = -0.46$, 95% CI $[-0.57, -0.34]$, and recent suicide attempters, $n = 49$, $M = -0.55$, 95% CI $[-0.64, -0.45]$. Thus, the fact that many patients in the control group showed evidence of previous suicide attempts may contribute to explain our failure to replicate Nock et al.'s (2010) first effect. That said, the proportion of patients with a lifetime history of suicide attempts (i.e., previous and recent suicide attempters) was quite similar in the original study and the present replication (57% and 62%, respectively). Thus, it is not entirely clear

whether differences in sample characteristics might account for our failure to replicate the original finding. This issue will be tackled further in the discussion.

Table 2

Hierarchical Logistic Regression Analysis Predicting Suicide Attempt During the 6-Month Follow-Up Period Among Baseline Suicide Attempters

	Estimate	SE	Odds ratio	<i>p</i>	95% Confidence interval (odds ratio scale)	
					Lower bound	Upper bound
Step 1						
Any Depressive Disorder	−0.088	0.83	0.916	.916	0.180	4.658
Multiple Suicide Attempts	0.356	0.552	1.527	.519	0.484	4.206
Step 2						
Beck Scale for suicide ideation	0.043	0.046	1.043	.353	0.954	1.142
Clinician Prediction	−0.066	0.147	0.936	.655	0.702	1.249
Patient Prediction	−0.055	0.247	0.946	.822	0.583	1.535
Step 3a						
S-IAT (continuous)	1.720	0.688	5.585	.012	1.450	21.513
Step 3b						
S-IAT bias (dichotomous)	2.336	0.714	10.340	.001	2.552	41.893

Note. *N* = 104. Dependent variable = Suicide attempt at 6-month follow-up. S-IAT = Suicide-Implicit Association Test.

Next, as in the Nock et al. (2010) study, we focused specifically on patients with a lifetime history of suicide attempts ($n = 104$) to test whether implicit associations between self and death/suicide predicted the occurrence of future suicide attempts at the 6-month follow-up. In this subsample, there were 16 patients who made suicide attempts during the follow-up period (one participant died by suicide). Consistent with our expectations, the S-IAT scores (continuous variable) were statistically significantly associated with suicide attempts at the 6-month follow-up, $OR = 5.28$, 95% CI [1.41, 19.77]. In the same way, S-IAT bias (dichotomous variable) strongly predicted suicide attempts at the 6-month follow-up, $OR = 9.72$, 95% CI [2.50, 37.73]. As in the original

study, the S-IAT scores predicted future suicide attempts after controlling for other clinical predictors, $OR = 5.58$, 95% CI [1.45, 21.51] (see Table 2). In the same way, the S-IAT bias statistically significantly predicted future suicide attempts beyond the other clinical predictors, $OR = 10.34$, 95% CI [2.55, 41.89] (Table 2).

Table 3

Classification Statistics for the Suicide-Implicit Association Test Prospectively

Predicting Suicide Attempts

Suicide attempt at 6-month follow-up		Sensitivity	Specificity	PPV	NPV	Accuracy
Yes	No					
IAT score > 0; $n = 6$	IAT score > 0; $n = 5$	37.50 [15.20, 64.57] (6/16)	94.18 [86.95, 98.09] (81/86)	54.55 [29.36, 77.60] (6/11)	89.01 [84.67, 92.24] (81/91)	85.29 [76.91, 91.53] (87/102)
IAT score < 0; $n = 10$	IAT score < 0; $n = 81$					

Note. $N = 102$. Scores on the Suicide-Implicit Association Test were dichotomized to indicate either a positive (IAT score > 0) or a negative (IAT score < 0) implicit bias toward suicide. NPV = negative predictive value; PPV = positive predictive value. 95% CI for the proportions are given in brackets and raw numbers are given in parentheses.

In the present study, the accuracy of the S-IAT in correctly identifying patients who had made a new suicide attempt within the 6-month follow-up period was 85%, 95% CI [76.91, 91.53] (see Table 3). In the original study, the accuracy was 75%, 95% CI [65.72, 84.19]. In this present study, the sensitivity (i.e., the probability that the test is positive, when a suicide attempt is present at follow-up) and the specificity (i.e., the probability that the test is negative, when a suicide attempt is absent at follow-up) of the test were 37%, 95% CI [15.20, 64.57], and 94%, 95% CI [86.95, 98.09], respectively. In

the original study, the sensitivity was 50%, 95% CI [23.04, 76.96], and the specificity was 80%, 95% CI [69.91, 88.67]. In the current study, the positive predictive value of the test (i.e., the probability of making a new suicide attempt within the 6-month follow-up period when the test is positive) was 54%, 95% CI [29.36, 77.60]. In the original study, the positive predictive value was 31%, 95% CI [18.92, 48.28]. The negative predictive value (i.e., the probability that a new suicide attempt is not present within the 6-month follow-up period when the test is negative) in the present replication was 89%, 95% CI [84.67, 92.24]. In the original study, it was also 89%, [95% CI = 83.83, 93.80].

Supplementary Analyses

We conducted supplementary analyses to determine whether the present findings (as reported in Table 2) are robust to different decisions that can be made regarding data analysis (exclusion of extreme observations, selection of patients, and statistical treatment of missing data). As shown in the SOM, the findings were similar, when the two extreme observations on the S-IAT scores were included into the analyses, even if inevitably, the data were messier (Table S3). In the same way, we found similar findings when all the observations ($N = 164$) were included in the analyses (Table S4), rather than when only patients with a lifetime history of suicide attempts were selected for the analysis.

We also found similar results when we relied solely on the hospital medical records (i.e., an objective indicator of suicide attempts) to determine whether the patient had made a new suicide attempt within the 6-month follow-up period (Table S5). Thus, the present results were not affected by patients' inability or unwillingness to report suicide attempts by phone.

Finally, we conducted sensitivity analyses to deal with missing data on the phone call measure of suicide attempts. Rather than assuming that there was no evidence of a suicide attempt when the patient could not be reached on the phone (as in the original study), we replaced missing data, using the multiple imputation technique. This technique is currently considered the best available method for dealing with missing data under the assumption that data are missing at random (see Thabane et al., 2013). As shown in the SOM (Table S6), the results were similar with this technique. Overall, results of the analyses suggested that the present findings are robust to different analytic choices.

Discussion

In the present study, we sought to replicate Nock et al.'s (2010) study. We found no evidence that patients who were admitted to the emergency department after a suicide attempt had statistically significantly stronger implicit associations between self and death/suicide than did those who presented for other psychiatric reasons. Nevertheless, as in the original study, we found that implicit identification with death/suicide strongly predicted future suicide attempts over 6 months, over and beyond other clinical predictors.

The present findings challenge the common assumption that implicit associations, and implicit bias more generally, have poor predictive validity (Jost, 2018). On the contrary, these findings add to recent research, showing that indirect measures of implicit cognition predict real-world behavior better than explicit measures (Faure et al., 2018; Kurdi et al., 2018; Nock & Banaji, 2007; Roland et al., 2018; Serra et al., 2019). The present findings also have clear clinical implications. Previous studies provided *prima facie* evidence for the predictive validity of the Suicide-Implicit

Association Test. However, all studies conducted thus far were conceptual, rather than direct replications of the original study, leaving open the possibility that some effects were exaggerated due to flexibility in data analysis. To the best of our knowledge, the present study is the first direct and independent replication of the original study. The findings provide substantial evidence that the Suicide-Implicit Association Test can be used to accurately identify patients who will make a suicide attempt in the near future. A straightforward implication for suicide prevention is that implicit identification with death/suicide should be assessed early, and patients with an implicit bias toward suicide should be given special attention and care.

In the present study, the Suicide-Implicit Association Test failed to discriminate patients who presented to the psychiatric emergency department for suicide attempts and those who presented for other reasons. However, this result seems to be due mainly to the high prevalence of previous suicide attempts in the control group. The data indicated that implicit association with death/suicide was lowest among patients with no history of suicide attempts, and highest among patients with a history of previous suicide attempts. Thus, the control group may have been too similar to the group of patients who had made a recent suicide attempt, to detect a statistically significant difference. Consistent with this, the proportion of patients with a lifetime history of suicide attempts was slightly larger in the present study than in the original study (62% vs. 57%). Another possible explanation is related to effect size. Research has indicated that effects with larger effect sizes tend to replicate better (i.e., more consistently) than do effects with smaller effect sizes (Open Science Collaboration, 2015). Thus, the failure to replicate the first effect reported by Nock et al. (2010), which had the lowest effect size in the original study, is consistent with this replication pattern. Of course, a

real effect should fail to replicate sometimes, especially if its effect size is low and the sample size modest.

As in Nock et al.'s (2010) original study, the accuracy of the implicit association test of predicting future suicide attempts during the 6-month follow-up period was impressively high (85%). This finding is important in the context of the current replication crisis. A number of recent large-scale replication projects have shown that about half of psychological studies failed to be replicated (Klein et al., 2018). In this context, the present direct and independent replication is reassuring, as it confirms the predictive validity of the Suicide-Implicit Association Test. Further studies are needed to explore how the predictive validity of the test could still be ameliorated, as it is clear that there is some room for improvement. In particular, the sensitivity of the test could be improved. However, the positive predictive value of 55% found in this study suggests that the test, in its present form, has some clinical significance. Considering the lack of reliable instruments, the Suicide-Implicit Association Test could be advantageously considered in the arsenal of clinical tools used to predict and prevent suicidal behavior.

Future studies are needed to better understand when, and how, implicit associations affect suicidal decision and behavior. Dual-process models (Fazio, 1990) suggest that implicit associations would predict suicidal behavior, especially when the motivation and the ability to exert control over one's impulsive reactions are limited. Many factors, such as chronic fatigue and substance intoxication, may dampen executive control. Further studies may test whether implicit association predicts suicidal behavior more strongly when control is depleted. This sounds like a promising line of inquiry, as it might contribute to explain the high prevalence of suicide rates in patients

suffering from major depression and addiction. Future studies may also examine whether implicit associations predict suicidal behavior more strongly, when patients are motivated to hide or dismiss their suicidal intent.

The main limitation of the present study rests in the difficulty of recruiting a large sample of patients in the immediate aftermath of a suicide attempt. Although the sensitivity, specificity, and positive and negative predictive values in the present replication study were very similar to the values found in the original study; these statistics should be interpreted with caution. In effect, suicide is statistically rare and the low base rate of suicide attempts renders any investigation of the determinants of suicide attempts a difficult enterprise. Further replications, using larger samples, are needed to extend the generality of the present findings. In particular, a large-scale multisite replication, involving patients from hospitals in different countries, would be much desirable.

To conclude, the present study is the first direct and independent replication of Nock et al.'s (2010) study. The results showed that the Suicide-Implicit Association Test prospectively predicts one of the most important decisions an individual can make, the decision to take one's life, as attested by official medical records. The clear message is that this surprising effect is robust and reproducible, offering new avenues for research and prevention.

Footnotes

¹ Because Nock et al. (2010) did not report the mean difference of S-IAT scores in their article, the confidence interval for the effect size could not be computed.

² The ethical committee deemed that it might be ethically problematic to terminate the task with the congruent blocks (Death + Me pairings). Thus, the order of the blocks was maintained constant for all participants. This is a methodological difference with the original study that should be kept in mind when interpreting the findings.

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